

Coloration in Wave Field Synthesis

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Introduction

Focus of evaluation of spatial audio systems is on spatial aspects

- key aspect we are working on
- relatively easy to investigate and to model

What other aspects do we have to consider?

Introduction

If it sounds bad, the spatial aspects don't matter

- artefacts can become audible for focused sources in WFS (Wierstorf 2013)
- perceived quality is determined by 70% by timbral aspects in 5.1 stereophony (Rumsey 2005)
- coloration in WFS?

Rumsey et al. (2005), On the relative importance of spatial and timbral fidelities in judgments of degraded multichannel audio quality, JASA

Wierstorf et al. (2013), Perception of Focused Sources in Wave Field Synthesis, JAES

Timbre

Timbre is most often defined as *that attribute of auditory sensation which enables a listener to judge that two nonidentical sounds, similarly presented and having the same loudness and pitch, are dissimilar* (ANSI 1994)

- similarly presented? \Rightarrow other authors used more explicit definition:
The label timbre combines all auditory object attributes other than pitch, loudness, duration, spatial location and reverberation environment. (Emiroglu, 2007)
- timbral space is multidimensional and underlying metric non-trivial

ANSI (1994), American National Standard Acoustical Terminology, ANSI S1.1-1994
Emiroglu (2007), Timbre perception and object separation with normal and impaired hearing, PhD-thesis, Oldenburg

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Coloration

Coloration can then be defined as *the difference of two points in the timbral space, whereby one of the points is the reference and the other point is colored.* (Brüggen 2001)

- has the reference point always a better quality?
- influence of concert halls is a desired coloration

Brüggen (2001), Klangverfärbungen durch Rückwürfe und ihre auditive und instrumentelle Kompensation, PhD-thesis, Bochum

Coloration and WFS

Why do we have coloration in Wave Field Synthesis?

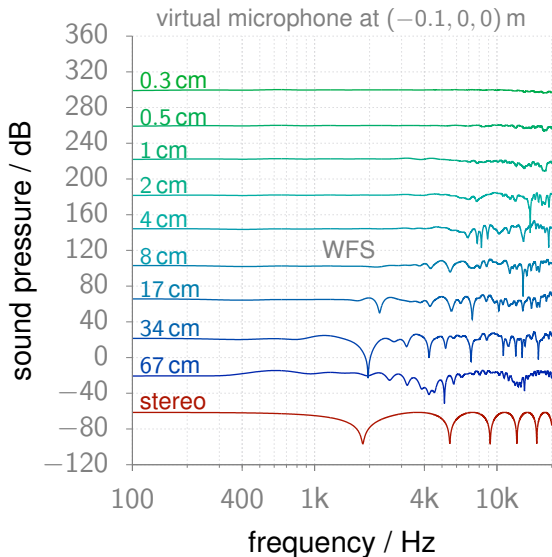
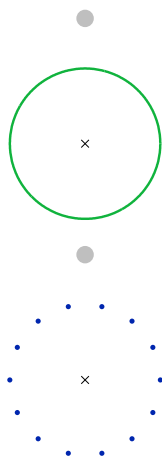
- WFS is implemented by delaying and weighting the same audio signal
- \Rightarrow highly correlated loudspeaker signals
- \Rightarrow comb-filter like spectrum

Research question:

- dependency on the number of used loudspeaker
- change with the listening position

Inter-System Coloration

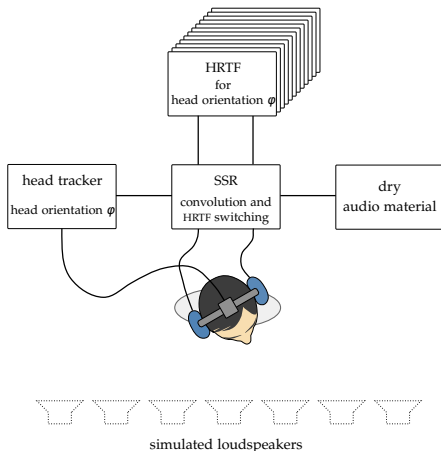
Experimental Setup



Inter-System Coloration

Experimental Setup

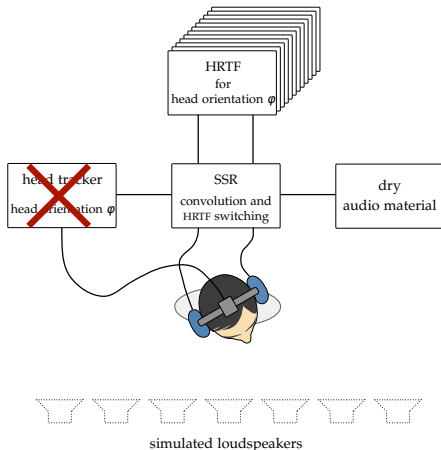
- 15 listeners
- pulsed pink noise + speech
- MUSHRA
 - point source as reference
 - 5 kHz high-pass as low anchor
 - 9 different WFS systems
 - stereophony
- static binaural simulation using non-individual HRTFs



Inter-System Coloration

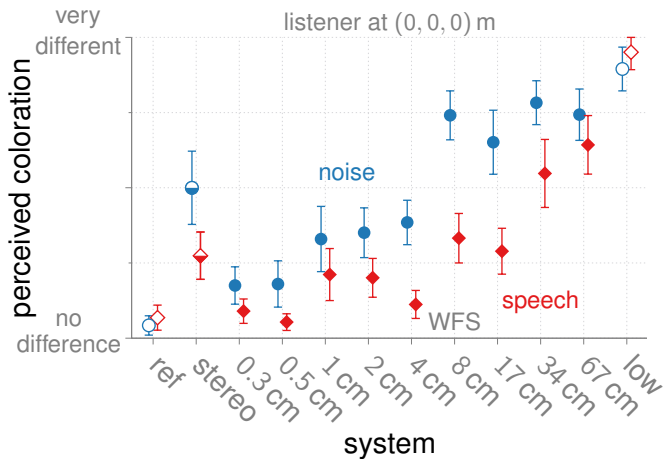
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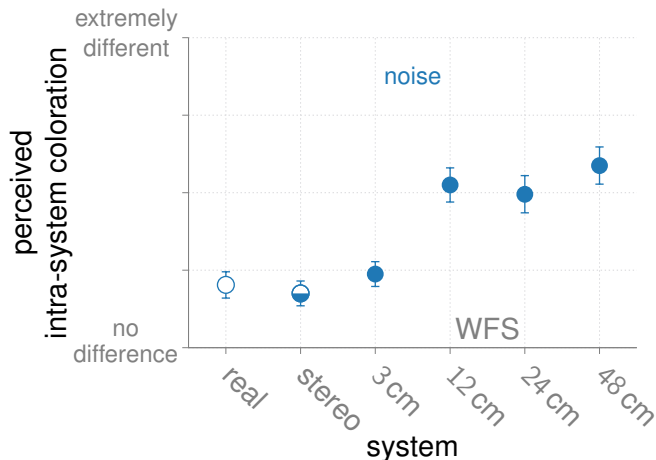
Inter-System Coloration

Results



Intra-System Coloration

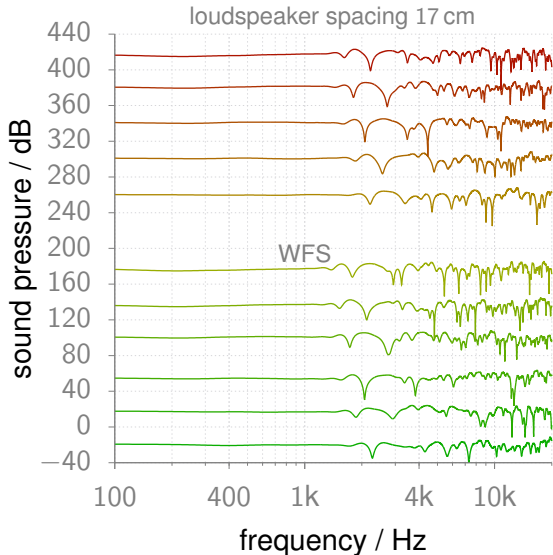
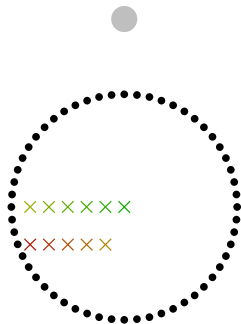
What happens if we move the source/listener within a system?



Wittek (2007), Perceptual differences between Wave Field Synthesis and stereophony, PhD-thesis, Surrey

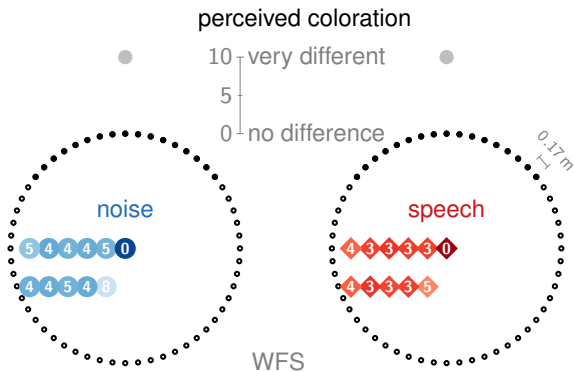
Intra-System Coloration

Experimental Setup



Intra-System Coloration

Results



Conclusions

- typical WFS systems show high amount of coloration
- both inter- and intra-system
- depends directly on the aliasing frequency
- temporal aspects of coloration crucial for focused sources in WFS (Wierstorf 2013)

Wierstorf et al. (2013), Perception of Focused Sources in Wave Field Synthesis, JAES

Questions?

<http://twoears.eu>

<http://spatialaudio.net>

<http://gnuplotting.org>

